

Retrofittable Power Supply

Technical Field:

The technical field is power supplies for electrical and electronic devices, and in particular, wireless power supplies for powering electronic devices such as personal computers.

Background:

Many electrical and electronic devices cannot be used in certain geographical regions because of the absence of AC or DC power to operate the devices. Other electronic or electrical devices are restricted geographically because the power supplies in these devices do not conform to the available power in terms of voltage and/or frequency. One solution is to produce portable versions of the electrical and electronic devices that can operate on self-contained power supplies, such as nickel-cadmium batteries or the like. Recently, fuel cell technology has been adapted to provide power for the portable electronic devices. U.S. Patent 6,057,051 discloses a miniaturized fuel cell assembly that can be adapted for use in a portable, or laptop computer. U.S. Patent 5,759,712 discloses a miniature fuel cell that can be adapted to a variety of purposes to power portable electronic devices, such as cellular telephones.

The above-noted patents disclose solutions for powering portable electronic devices. Because they are intended to be portable, the electronic devices must be designed to include specific features, such as light weight, small size, and most importantly, low power consumption. Thus, the design of a portable electronic device necessarily considers the availability of a power supply that can fit the device's design parameters of light weight and small size, and yet can deliver sufficient power to operate the device for a sustained period. Such design constraints (portability, low power consumption) often lead to lower performance capabilities compared to corresponding non-portable devices, and to greatly increased costs of manufacture.

While electrical and electronic devices that are not designed to be portable (including design limits on power consumption) cannot be used in geographical regions where power is unavailable, these non-portable devices also are generally less expensive to manufacture, and provide for better performance than their portable counterparts. For example, a desktop personal computer may operate at a higher clock speed, have a larger memory and mass storage, and cost less, than a laptop, or portable personal computer. Thus, achieving the best performance at the lowest cost is not consistent with the concept of portability.

1 **Summary:**

2 A retrofittable power supply allows an electronic device that is initially designed
3 to be non-portable (in the sense that such electronic and electrical devices require a wired
4 connection to an AC or DC power supply) to operate in geographical regions, or under
5 conditions, in which a wired power supply is not available. The retrofittable power
6 supply can simply plug into an existing case or frame of the non-portable electronic
7 device, and can then serve as a means for powering both the non-portable electronic
8 device, as well as a means for powering peripheral devices that may be coupled to the
9 non-portable electronic device.

10 In an embodiment, the retrofittable power supply comprises a housing having a
11 form factor equivalent to a conventional, wired power supply. The housing includes a
12 power generation section. The power generation section may comprise a fuel cell, or
13 otherwise incorporate advanced fuel cell technology. The power generation section may
14 include, as part of the fuel cell, a water holding and disposal module. The water holding
15 and disposal module may comprise water absorption means, which may include
16 commercially available materials that absorb and hold water generated by the fuel cell.
17 The water holding and disposal module may also include a water tank to hold excess
18 water generated by the fuel cell. The water holding and disposal module may also
19 include means for disposal of excess water. In an embodiment, the water disposal means
20 comprises a fan that accelerates evaporation of the excess water. Alternatively, or in
21 addition, heat generated by operation of the fuel cell may be used to speed evaporation.
22 In another embodiment, excess water may be drained from the water holding and disposal
23 module. Such drainage may be facilitated by a manually or automatically operated valve,
24 and a piping arrangement that diverts the draining water from components of the non-
25 portable electronic device.

26 The retrofittable power supply may also comprise DC/AC power converter to
27 supply AC power. The AC power may be supplied at one or more AC power out fixtures
28 to enable operation of peripheral devices associated with the non-portable electronic
29 device.

30 In another embodiment, the retrofittable power supply may include a power
31 storage module. The power storage module may be a rechargeable battery, for example.
32 The power generation module then provides DC power to the power storage module for
33 subsequent delivery to one or more components of the non-portable electronic device or
34 to one or more peripheral devices.

1 A specific application of the retrofittable power supply is to replace a
2 conventional, wired power supply in a desktop personal computer. The conventional,
3 wired power supply is simply removed, and is replaced by the retrofittable power supply.
4 The AC power out section of the retrofittable power supply provides AC power to
5 peripheral devices such as a monitor and a printer, for example. When using a fuel cell in
6 the power generation module, the fuel source will eventually have to be replenished. This
7 may be accomplished by replacing the entire retrofittable power supply with a new
8 retrofittable power supply. Alternatively, a fuel supply in the fuel cell may simply be
9 renewed. For example, in a fuel cell using liquid methanol carried in a fuel tank, the tank
10 can be refilled or simply replaced.

11 Other power sources besides fuel cells may be used in the power generation
12 module. For example, the power generation module may use a radioactive material, such
13 as plutonium 239, to generate heat energy, which is then converted into electrical energy.
14 Other possible power generation means can include small turbines or solar devices.
15 Power storage means may include, in addition to conventional batteries, fly wheel storage
16 devices, and devices that convert the heat generated by operation of the fuel cell into
17 electrical power for subsequent storage.

18 **Description of the Drawings:**

19 The detailed description will refer to the following drawings, in which like
20 numerals refer to like items, and in which:

21 Figure 1 illustrates a typical non-portable electronic device having a conventional
22 wired power supply;

23 Figure 2 illustrates the conventional wired power supply from the non-portable
24 electronic device of Figure 1;

25 Figure 3 illustrates a retrofittable power supply adaptable to replace the
26 conventional power supply shown in Figure 2;

27 Figure 4 is a cross sectional view of the retrofittable power supply of Figure 3;
28 and

29 Figure 5 illustrates an alternative retrofittable power supply adapted for use with
30 the non-portable electronic device of Figure 1.

31 **Detailed Description:**

32 To provide non-wired power to a non-portable device, a retrofittable power supply
33 uses a same form factor as an existing conventional, wired power supply used in the non-
34 portable device. The non-portable device may be a desktop personal computer, for

1 example. In an embodiment, the retrofittable power supply may use fuel cell technology
2 to generate DC power. Alternative means for developing power include devices or
3 materials that generate heat, which can subsequently be converted to electrical energy.
4 An example of such a heat-generating material is plutonium 239. Other devices for
5 generating electrical power include a solar power device and a wind turbine.

6 A fuel cell is an electrochemical apparatus wherein chemical energy generated
7 from a combination of a fuel with an oxidant is converted to electric energy in the
8 presence of a catalyst. The fuel is fed to an anode, which has a negative polarity, and the
9 oxidant is fed to a cathode, which, conversely, has a positive polarity. The two electrodes
10 are connected within the fuel cell by an electrolyte to transmit protons from the anode to
11 the cathode. The electrolyte can be an acidic or an alkaline solution, or a solid polymer
12 ion-exchange membrane characterized by a high ionic conductivity. A typical fuel cell
13 uses a solid polymer electrolyte. The solid polymer electrolyte is often referred to as a
14 proton exchange membrane (PEM).

15 In fuel cells employing liquid fuel, such as methanol, and an oxygen-containing
16 oxidant, such as air or pure oxygen, the methanol is oxidized at an anode catalyst layer to
17 produce protons and carbon dioxide. The protons migrate through the PEM from the
18 anode to the cathode. At a cathode catalyst layer, oxygen reacts with the protons to form
19 water. The anode and cathode reactions in this type of direct methanol fuel cell are
20 shown in the following equations:

21 Anode reaction: $\text{CH}_3\text{OH} + \text{H}_2\text{O} \rightarrow 6\text{H}^+ + \text{CO}_2 + 6\text{e}^-$

22 Cathode reaction: $3/2 \text{O}_2 + 6\text{H}^+ + 6\text{e}^- \rightarrow 3\text{H}_2\text{O}$

23 The essential requirements of typical fuel cells include: first, the fuel cell requires
24 efficient delivery of fuel and air to the electrode, which typically requires complicated
25 microchannels and plumbing structures. A second requirement is that the fuel cell should
26 provide easy access to the catalyst and a large surface area for reaction. This second
27 requirement can be satisfied by using an electrode made of an electrically conductive
28 porous substrate that renders the electrode permeable to fluid reactants and products in
29 the fuel cell. To increase the surface area for reaction, the catalyst can also be filled into
30 or deposited onto a porous substrate. However, these modifications result in a fragile
31 porous electrode that may need additional mechanical support, such as by use of a fiber
32 matrix. Alternatively, the electrode can be made of an etched porous Vycor glass
33 substrate or an etched-nuclear-particle-track membrane substrate to improve its toughness

1 and strength. A third requirement is close contact between the electrode, the catalyst, and
2 the PEM. The interface between the electrode and PEM is a discontinuity area as
3 concerns the electric current transmission wherein the charge carriers are the electrons, on
4 one side, and the protons on the other side. A solution to this problem has been attempted
5 by hot pressing of the electrodes onto the PEM (U.S. Patent No. 3,134,697). Another
6 solution suggests the intimate contact of the catalytic particles with a protonic conductor
7 before interfacing the electrode with the electrolyte (U.S. Patent No. 4,876,115). Other
8 solutions are described in U.S. Patent Nos. 5,482,792 and 6,022,634. A fourth
9 requirement is that the fuel cell should provide for humidity control of the electrode. The
10 PEM requires water to be effective in conducting protons. However, since it operates at a
11 higher temperature than its surroundings, the PEM tends to dehydrate during operation.
12 The typical method of re-hydrating the PEM is to capture water in the exhaust stream and
13 circulate it back to the PEM.

14 Figure 1 illustrates a non-portable electronic device 1 including a conventional,
15 wired power supply. The non-portable electronic device 1 illustrated in Figure 1 is shown
16 as a desktop computer. The non-portable electronic device 1 includes a housing 3 in
17 which components of the personal computer are maintained, and a power supply 10. The
18 power supply 10 includes a device for converting AC power to DC power for subsequent
19 supply to components of the personal computer, means for supplying the AC power to
20 peripheral devices associated with the personal computer, and a cooling fan (not shown)
21 for removing heat generated by the power supply 10. Power is provided to the power
22 supply through transmission means 14, which is a conventional AC power cord.

23 Figure 2 illustrates the power supply 10 in more detail. The power supply 10
24 includes the AC/DC conversion module 13, cooling fan section 12 and the power supply
25 cord 14. As shown in Figure 2, the power supply 10 is built to specific dimensions a, b
26 and c. The dimensions a, b and c may be specified as industry standard values for a
27 typical personal computer. Other industry standards or criteria for the power supply 10
28 may include input voltage and frequency output voltage, location of electrical
29 connections, power (watts) generated, limits on heat generated, and other
30 criteria/characteristics. In this way, any wired power supply unit may be substituted for
31 the power supply 10 shown in Figure 2. The dimensions and other criteria that determine
32 the shape and other characteristics of the power supply 10 are here referred to as the form
33 factor of the power supply 10.

1 A limitation of the non-portable electronic device 1 shown in Figure 1 is that the
2 device cannot be operated in any area where electrical power is not readily available.
3 Furthermore, the device 1 may be designated or designed to operate with power delivered
4 at a certain frequency or voltage level. The device 1 may not be usable in all
5 geographical regions, particularly those regions that supply electrical power at
6 frequencies and voltages that are not compatible with the power supply 10. Thus,
7 operation of the electronic device 1 may be limited to certain geographical regions,
8 diminishing its value.

9 ~~To solve this geographical use limitation and other problems inherent in the power~~
10 supply 10 shown with the non-portable electronic device 1, a retrofittable power supply
11 100 having a same form factor as the power supply 10 shown in Figure 2, is provided as
12 shown in Figure 3. The retrofittable power supply 100 includes a power generation
13 module 101, a cooling module 103, and a DC/AC generation module 105. As illustrated
14 in Figure 3, the retrofittable power supply 100 has dimensions a, b and c equal to the
15 corresponding dimensions a, b and c shown for the power supply 10 in Figure 2. Other
16 characteristics of the retrofittable power supply 10 may be made to coincide with those of
17 the power supply 10. Accordingly, the retrofittable power supply 100 may simply be
18 ~~inserted into the framework or bay normally used to house the power supply 10.~~

19 In an embodiment, the power generation module 101 may be a fuel cell, or
20 otherwise incorporate fuel cell technology. The fuel cell may be a proton exchange
21 membrane fuel cell, for example. Excess water generated by the fuel cell may be held or
22 disposed of through the power generation module 101.

23 The DC/AC conversion module 105 includes means for converting DC power
24 generated by the power generation module 101 into AC power for further supply to
25 components of the non-portable electronic device 1 and as the power supply for
26 peripherals that may be associated with the non-portable electronic device 1, including a
27 computer monitor and a printer, for example.

28 The cooling module 103 may be used to remove excess or waste heat generated by
29 the power generation module 101. In an embodiment, the cooling module 103 may
30 comprise a cooling fan. Alternatively, the cooling module 103 may be implemented as a
31 series of fins that provide for radiant heat transfer from the power generation module 101.
32 Other conventional means of removing waste heat generated by the power generation
33 module may also be incorporated into the cooling module 103. Finally, the cooling
34 module 103 may return some waste heat to the power generation module 101, for

1 example, to help with evaporation of excess water retained by the power generation
2 module 101.

3 Figure 4 is a cross sectional view of the power generation module 100, embodied
4 as a fuel cell. The power generation module 101 includes a fuel cell 111 and a water
5 retention mechanism 113. Water retention and disposal means are described in detail in
6 U.S. Patent 6,057,051, hereby incorporated by reference. The water retention means
7 include super absorbent polymers such as a polyacrylate cross-link material and a starch-
8 polyacrylate graphed copolymer cross-link material. Other water retention means may
9 include a small water tank.

10 Figure 5 shows an alternative embodiment of a retrofittable power supply 120.
11 The retrofittable power supply 120 includes power generation module 121, power storage
12 module 123, DC-AC conversion module 127, cooling module 125, and AC power out
13 connection 129. The power generation module 121 may be a proton exchange membrane
14 fuel cell, for example. The power generation module 121 may generate DC power that is
15 subsequently stored in the power storage module 123. Alternatively, or in addition, the
16 power generation module 121 may provide DC power directly to components of the non-
17 portable electronic device 1 shown in Figure 1, and provide, in parallel, power to the
18 power storage module 123. The power storage module 123 may be a conventional
19 rechargeable battery, for example. Other technology such as a fly wheel device may also
20 be used in the power storage module 123. Use of the power storage module 123 may
21 ensure a constant supply of power to the non-portable electronic device 1 during times
22 when the power generation module 121 is not generating electrical power at a sufficient
23 rate to supply the components of the non-portable electronic device 1. The DC/AC
24 conversion module 127 and the cooling module 125 may operate in a manner similar to
25 corresponding devices shown in Figure 3.

26 In operation, the retrofittable power supply 100, shown in Figure 3, provides DC
27 and AC power to various components and peripherals associated with the non-portable
28 electronic device 1, shown in Figure 1. The retrofittable power supply 100 may be
29 replaced when the power generation module 101 is no longer capable of generating
30 electrical power. For example, in a power supply in which fuel cell technology is
31 employed when the fuel available, (e.g., liquid methanol) is exhausted, the fuel cell will
32 not longer be able to generate electrical power, and the retrofittable power supply 100
33 may be replaced with a replacement retrofittable power supply having a fully charged fuel
34 cell. Alternatively, the power generation module 101 using fuel cell technology may

1 employ a refillable fuel supply. In this embodiment, when the fuel cell is no longer
2 capable of generating electrical power, the retrofittable power supply 100 may be
3 removed from the non-portable electronic device 1, and the refillable fuel supply may be
4 refilled with fuel, such as liquid methanol.

5 Using the retrofittable power supply 100 or 120, or similar devices, many non-
6 portable electrical and electronic devices may be used in areas that either do not provide
7 electrical power, or provide electrical power at a frequency and/or voltage that is non-
8 compatible with the non-portable electronic or electrical device. This allows low cost,
9 and relatively high performance electronic and electrical devices to be used in situations
10 in which previously, only portable electrical and electronic devices could be used.

10016648-1